

Education and religious participation: city-level evidence from Germany's secularization period 1890–1930

Sascha O. Becker^{1,2,3,4,5,6,7} · Markus Nagler⁸ ·
Ludger Woessmann^{2,3,4,5,7,8}

Published online: 4 March 2017

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Abstract Why did substantial parts of Europe abandon the institutionalized churches around 1900? Empirical studies using modern data mostly contradict the traditional view that education was a leading source of the seismic social phenomenon of secularization. We construct

Valuable comments were kindly provided by the editor, five anonymous referees, Oliver Falck, David Figlio, Jared Rubin, and seminar participants at Stanford, Gothenburg, Hong Kong UST, Modena, the Graduate Institute of International and Development Studies in Geneva, Umeå, the Max Planck Institute for Research on Collective Goods in Bonn, the CAGE/CEPR Conference on “Long-Run Growth: Unified Growth Theory and Economic History” at Warwick, the CAS conference on “The Long Shadow of History” in Munich, the CEPR Economic History Symposium in Perugia, the CESifo Economics of Education area meeting in Munich, the European Economic Association in Gothenburg, the Economic History Society in Warwick, the Association for the Study of Religion, Economics, and Culture at Chapman University, the German Economic Association in Hamburg, the Ammersee workshop “Natural Experiments and Controlled Field Studies”, the Education Committee of the German Economic Association in Wuppertal, and the workshop “Political Economy, Economic History, and Religion” at WZB Berlin. We are grateful to Lucian Hölscher for providing the Sacrament Statistics, to Christoph Albert, Laurenz Detsch, and Andreas Ferrara for capable research assistance, and to the Pact for Research and Innovation of the Leibniz Association for partial financial support.

✉ Sascha O. Becker
s.o.becker@warwick.ac.uk

Markus Nagler
markus.nagler@econ.lmu.de

Ludger Woessmann
woessmann@ifo.de

¹ Department of Economics, University of Warwick, Coventry CV4 7AL, UK

² Centre for Competitive Advantage in the Global Economy (CAGE), Coventry CV4 7AL, UK

³ Ifo Institute, Poschingerstr. 5, 81679 Munich, Germany

⁴ CESifo, Poschingerstr. 5, 81679 Munich, Germany

⁵ ROA, University of Maastricht, The Netherlands

⁶ CEPR, London, UK

⁷ IZA, Bonn, Germany

⁸ Department of Economics, University of Munich, Germany

a unique panel dataset of advanced-school enrollment and Protestant church attendance in German cities between 1890 and 1930. Our cross-sectional estimates replicate a positive association. By contrast, in panel models where fixed effects account for time-invariant unobserved heterogeneity, education—but not income or urbanization—is negatively related to church attendance. In panel models with lagged explanatory variables, educational expansion precedes reduced church attendance, while the reverse is not true. Dynamic panel models with lagged dependent variables and instrumental-variable models using variation in school supply confirm the results. The pattern of results across school types is most consistent with a mechanism of increased critical thinking in general rather than specific knowledge of natural sciences.

Keywords Secularization · Education · Modernization · Long-run development

JEL Classification Z12 · N33 · I20

1 Introduction

Secularization, understood as churches' loss of importance in society, is a European phenomenon that was particularly strong during the late nineteenth and early twentieth century and brought fundamental change to societies. Important aspects of this can be observed from the practice of religious participation. For example, in our micro-regional German data, participation in Holy Communion per Protestant declined on average by nearly a third of its initial value from 1890 to 1930. Understanding the sources of this seismic religious change is important: by shaping attitudes towards factors such as education and knowledge diffusion, the religious orientation of society may have important repercussions for long-run development (Glor 2011).¹ Furthermore, while it is hard to observe changes in religious beliefs in the historical context, declining religious participation in itself has important societal meaning because of the historical role of the institutionalized church in society at large. However, despite heated academic debates, empirical evidence on the sources of this dramatic social change is scarce. In this paper, we use city-level panel data to estimate how advanced education affected religious participation in Germany's secularization period around the turn to the twentieth century.

Classic secularization hypotheses suggest economic development and education as two dimensions of modernization that may affect religious participation. Our focus is on the effect of education. As argued by many eminent scholars, increased education may have been a leading source of secularization because increased critical thinking and advanced scientific knowledge may have reduced belief in supernatural forces (e.g., Hume 1757 [1993]; Freud 1927 [1961]; cf. McCleary and Barro 2006a). Cross-sectional evidence generally contradicts this view and finds a positive association between education and church attendance (Iannaccone 1998), and modern cross-country and individual panel analyses come to mixed results. However, it is unclear how these results transmit to the context of actual decade-long societal developments during important historical phases of secularization.

To provide evidence from an historical setting of massive secularization, this paper constructs a unique panel dataset on education and Protestant church attendance in German cities from 1890 to 1930. This dataset allows us to estimate panel models with fixed effects that exploit city-specific variation over time. While cross-sectional associations between educa-

¹ For a direct link of secularization and long-run economic growth through identity choice, see Strulik (2016).

tion and religious participation may well emerge from bias due to omitted variables—for example, more orderly people may go both to church and to school—the use of city and year fixed effects takes out unobserved time-invariant city characteristics and common trends.

In our panel fixed effects models, we find that enrollment increases in advanced schools are significantly related to decreases in church attendance. These panel estimates are in strong contrast to cross-sectional models, which indicate a positive cross-sectional association between advanced education and church attendance in the same data. In contrast to education, changes in measures of income (municipal tax, income tax, or teacher income) and urbanization (city population) as alternative dimensions of modernization are not significantly related to changes in church attendance, confirming recent related work at the county level (Becker and Woessmann 2013).

The main result is confirmed in a series of robustness tests. In particular, we control for contemporaneous changes in potentially confounding variables such as the demographic composition of the city (age and gender structure and migration patterns), the educational environment (opening of universities and emergence of secular schools), the economic environment (industry structure and welfare expenditure), and the political environment (emergence of secular movements and nationalistic sentiment). Results are also robust in alternative specifications of the education variable and in subsamples.

The significant negative effect of advanced-school enrollment on church attendance is also confirmed in dynamic panel models. First, models with different lag structures of the education variable indicate that the effect of advanced-school enrollment is strongest after about 10 years (the second lag), speaking against bias from reverse causation and suggesting that the effect of advanced education on religious participation materializes over time. By contrast, lagged church attendance does not predict advanced-school enrollment. Second, results are robust in models with lagged dependent variables to account for persistence in church attendance over time. Third, while a demanding specification in our setting, basic results are also robust to the addition of city-specific linear time trends.

Results are also confirmed in an instrumental-variable specification that uses the number of advanced schools in a city as an instrument for advanced-school enrollment. To avoid identification from potentially endogenous demand-side enrollment decisions, this model restricts the analysis to changes in the supply of schools and exploits variation in advanced-school enrollment that originates from the opening and closing of advanced schools in a city.

Finally, we use enrollment in different types of advanced schools that have different curricula to explore potential mechanisms of the effect of advanced-school enrollment on religious participation. While imprecisely estimated, the coefficients of the different school types indicate that results are at least as strong for the classical *humanistisches Gymnasium* with its curriculum focused on classical languages (and for the *Realgymnasium* with its focus on modern languages) as for the newly emerging *Oberrealschule* with its strong curricular focus on natural sciences. This pattern is more consistent with a leading role for the general conveyance of critical thinking in advanced schools in undermining belief in the institutionalized church than with a specific role for the teaching of scientific knowledge of facts of natural sciences.

Our paper addresses the effect of advanced education on religious participation in a leading historical period of secularization, using city-specific variation within one country over several decades. As such, it complements the existing literature on the effects of education on secularization that uses cross-country or modern-day individual-level variation (as summarized in greater detail in Sect. 2.2 below) by providing insights into the mechanisms and reasons of a fundamentally important social phenomenon in Europe in the late nineteenth and

early twentieth century. It is particularly noteworthy that in our context, the cross-sectional pattern is turned around in the panel analyses, suggesting that the cross-sectional identification is likely to suffer from severe identification problems. Our panel evidence suggests that in the historical context of Germany around the turn to the twentieth century, educational expansion was negatively related to religious participation, confirming traditional secularization hypotheses during an historical period of mass secularization when these lines of reasoning were very prominent but lacked empirical validation.

In what follows, Sect. 2 provides a conceptual background and reviews the literature. Section 3 gives the historic and institutional background for Germany at the turn of the twentieth century. Sections 4 and 5 introduce our data and empirical model. Section 6 reports our basic results and different robustness checks. Sections 7 and 8 extend the analysis to dynamic panel models and instrumental-variable estimation, respectively. Section 9 explores specific mechanisms by analyzing effects of different types of advanced schools that have different curricula. Section 10 concludes.

2 The role of education in secularization

To frame the empirical analysis of this paper, we start by providing a conceptual background. We introduce the concept of secularization and its relationship with education and economic development as discussed in modernization theories and summarize the available empirical evidence on the relationship between education and religious participation.

2.1 Conceptual background

Secularization A standard dictionary definition of secularization is that “Secularization is the transformation of a society from close identification with religious values and institutions toward nonreligious values and secular institutions.”² This definition shows the multi-faceted nature of the general concept of secularization that needs specification in our concrete historical context.

Contemporaries noted a marked decline in church attendance between 1870 and World War I (WW I) and were concerned about the “decay” in religiosity (see Hölscher 2005). Church attendance was interpreted as an indicator of a seismic change in society. Nipperdey (1988) confirms the loss in churchliness at the time and draws on selected statistics of the Protestant and Catholic churches to illustrate the process of secularization.

Following this empirical tradition, in our analysis we draw on statistics on participation in Holy Communion that we describe in more detail below. Given the lack of surveys in this early period, it is obviously impossible to capture directly what went on in people’s minds and whether decreased involvement in church went hand in hand with a loss of faith, or whether it was merely an expression of lack of interest in religious services provided by the church. But clearly the church used to be one of the pillars of society in Prussia and the German Empire: in 1861, the Prussian King Wilhelm I, who went on to become Germany’s first Emperor, was crowned in a church: the castle church of Königsberg. Several churches in Berlin commemorate German emperors and their family: the *Kaiser-Wilhelm-Gedächtniskirche* commemorates Wilhelm I, the *Kaiserin-Augusta-Kirche* commemorates his wife Augusta von Sachsen-Weimar-Eisenach, the *Kaiser-Friedrich-Gedächtniskirche* commemorates Emperor Friedrich III who reigned for only 99 days in 1888. Given this

² Wikipedia 2016, accessed 25 Oct 2016 <https://en.wikipedia.org/wiki/Secularization>.

prominence of the church in public life, the marked decrease in support for the church is remarkable and warrants an analysis of the factors behind it during this period of rapid change.

Secularization hypotheses take various forms (see [McCleary and Barro 2006b](#)) and highlight the fact that different dimensions of modernization may have differing relevance for religious participation. On a broad scale, we may distinguish between aspects of economic development and aspects of education.

Economic development and secularization There are at least two important aspects of economic development that have been discussed as potential factors affecting secularization— income and urbanization. First, the income aspects is nicely captured by the remark of [Marx \(1844\)](#) about religion as “opium of the people” (p. 72) that is required to alleviate the ailments of poor economic conditions. Along this line of argument, improved material conditions may reduce demand for religious consolation and hence reduce church attendance. [Becker and Woessmann \(2013\)](#) address the relation of income and secularization for the historical context studied here and find no effect of increased income on church attendance in a sample of Prussian counties. Their sample differs from this paper in two dimensions: here, we use data at the city rather than county level and cover data from across the German Empire, not just Prussia.

Second, a closely related but conceptually distinguishable aspect of economic development is urbanization. Urbanization went along with migration from rural to urban areas, and the adjustment to a new environment brought challenges of its own. On the demand side, a new life in a city environment might have led to an increased interest in attending church in order to meet new people. At the same time, if church attendance in the rural place of origin took place under pressure from relatives and acquaintances, life in the city allowed movers to go their own ways and skip church without being penalized. On the supply side, rapid urbanization might have led to an under-supply of religious services: as already noted by [Durkheim \(1897\)](#), p. 161, the number of Protestant pastors did not keep up with rising population numbers in Germany.³ At the same time, urban areas come with higher opportunity costs of religious participation. Cities offer many alternative time uses such as museums and theaters (see [McCleary and Barro 2006b](#), p. 152).

Education and secularization Apart from economic development, education has been discussed as a separate dimension of modernization with a bearing on secularization during the nineteenth and twentieth centuries. In the German context, [Nipperdey \(1988\)](#) narratively attributes the decline in churchliness to increases in urbanization, technological progress, and the advancement of a rational view on the world. Increased education may have been a leading source of demand-induced secularization, even after controlling for income and urbanization. In one form or another, this view on education and religiosity has been advanced by such eminent scholars as [Hume \(1757 \[1993\]\)](#), [Marx \(1844\)](#), [Weber \(1904 \[2001\]\)](#), and [Freud \(1927 \[1961\]\)](#), among many others.

There are again two separate general aspects of education discussed as possible determinants of secularization, which we may refer to as critical thinking and scientific knowledge. First, education may foster critical thinking. The education ideal introduced by Wilhelm von Humboldt at the beginning of the nineteenth century, which governed the Prussian education system at the time, was a holistic one: to integrate the arts and sciences with research to achieve both comprehensive general learning and cultural knowledge. To the extent that this

³ While our analysis contributes to testing of “demand-side” secularization hypotheses, there is substantial evidence that elements of a “supply-side” religion-market model also contribute to understanding religiosity (e.g., [Finke and Iannaccone 1993](#); [Stark and Iannaccone 1994](#); [McCleary and Barro 2006b](#)). [Gruber and Hungerman \(2008\)](#) show that church attendance faces competition from secular time uses.

education ideal leads to emancipation of thinking, students may increasingly oppose established “old-fashioned” institutions such as the church. This may or may not go hand in hand with changing religious beliefs. Still, to the extent that sermons are an important channel by which the church can exert influence over its members, reduced church attendance likely implies a loss of influence in society and its development.

Second, schools may also teach scientific knowledge and findings that may be conceived as being in direct opposition to established religious beliefs. McCleary and Barro (2006b) summarize this view as follows: “one argument for secularization is that more educated people are more scientific and are, therefore, more inclined to reject beliefs that posit supernatural forces” (p. 151).⁴ While the school curriculum featured religious education all the way throughout our sample period, it is clear that students were exposed as well to scientific discoveries that had the potential to challenge religious views. Some may have concluded that God and the church as provider of religious services are no longer necessary to make sense of the world and to cope with life. Increased education may thus have translated into lower church attendance.

Education may influence church attendance directly via its effect on students themselves who no longer go to church. It may also exert indirect effects, for example, via table talks with parents or via a changing intellectual climate in a city. For example, Thomas Mann’s novel *Die Buddenbrooks* that traces the life of a German nineteenth-century dynasty over several generations famously exemplifies both the decline in attachment to religion and the central role played by conversations in exchanging views across several generations of the family. Interestingly, during the period of analysis natural history museums were founded across German cities and several natural-science magazines started publication. For example, *Der Naturforscher*, a weekly magazine started in 1868 “to promote the advances of the natural sciences” and explicitly targeted the educated of all classes (*für Gebildete aller Berufsklassen*). In an environment where scientific ideas are being taught and consumed by children and adults alike, it may no longer be unspeakable to question God’s existence or the importance of church in society.

Implications for the empirical analysis and its interpretation The focus of this paper is to investigate how education affected religious participation during Germany’s secularization period around the turn to the twentieth century. Because education is correlated with income and urbanization, it may be empirically challenging to separately identify their effect. In an attempt to isolate the effect of changes in education above and beyond changes in income and urbanization, all our empirical models will take these alternative mechanisms of economic development into account. In addition, Sect. 6.4 provides detailed analyses and discussion of the bearing of different measures of economic development, considered jointly and individually, for our results on education.

Our empirical analysis will also address specific mechanisms by which education may affect religious participation. Apart from the possible effects of education working through income and urbanization, Sect. 6.2 will analyze the extent to which the empirical effect of education on church attendance is mediated by contemporaneous changes in a series of other factors such as the sectorial structure of the economy, the emergence of secular movements, or nationalistic sentiment that may in part capture mechanisms by which education affects church attendance. In Sect. 9, we make use of the differential curricula of different types of advanced schools to differentiate between critical thinking and scientific knowledge as two separate possible mechanisms by which education may affect religious participation.

⁴ Modern psychological literature suggests that, while religiosity comes natural at early age, rational reflection can reduce it (Bloom 2007; Kapogiannis et al. 2009; Shenhav et al. 2012).

Ultimately, our empirical analysis will thus capture one important dimension of secularization in the form of lower church attendance and demonstrate that it is partly driven by increased enrollment in advanced schools, in particular in those types that may mostly convey critical thinking in general. These empirical results do not imply that advanced scientific knowledge is incompatible with belief in God or that education is generally hostile to religious participation. They show that, in this historical setting, increased advanced schooling was related to declining church attendance, an indication of secularization understood as the loss of influence of the organized church. Education may well have led people who believe in God to break with the institution of the church, without weakening their belief in God. It is also possible that, for example, people who did not have a strong belief in God in the first place were led by education to abandon their custom of attending church. Still, the results show that increases in advanced education were closely related to people's reduced active involvement with the institutionalized church and its rituals, one of the most seismic changes in social history since the nineteenth century.

2.2 Existing evidence on education and secularization

Despite heated academic debates about secularization, empirical evidence on the sources of this phenomenon is scarce. In the sociological literature, this debate has been going on for a long time (Sherkat and Ellison 1999). The existing evidence, which is mostly cross-sectional, is generally not in line with the traditional view that education reduces church attendance. Iannaccone (1998) summarizes the literature as follows: "In numerous analyses of cross-sectional survey data, rates of religious belief and religious activity tend not to decline with income, and most rates increase with education" (p. 1470).

Similarly, in a cross-country analysis, McCleary and Barro (2006b) find that while religiosity is negatively related to overall economic development,⁵ it is actually positively related to education. A positive effect of education on religiosity could be explained by alternative hypotheses based on advantages of educated people in the kind of abstract thinking required for religion (McCleary and Barro 2006b) or based on educated people getting higher returns from social networking in church (Glaeser and Sacerdote 2008). In contrast, Ruiter and Tubergen (2009), Bettendorf and Dijkgraaf (2010), and Deaton (2011) find negative associations of education with indicators of religiosity in cross-country analyses, although not uniformly across all countries.

It is, however, not clear to what extent the existing cross-sectional findings suffer from omitted-variable bias. For example, in cross-sectional studies finding a positive association between education and church attendance, it is easily conceivable that more orderly people are more inclined to go both to church and to school, that more conservative people put particular emphasis on religious rituals and on educational achievement, or that communities that are more inclined to collective action organize educational infrastructure and enjoy church community. These examples would give rise to a positive correlation between education and

⁵ Paldam and Gundlach (2013) and Herzer and Strulik (2016) confirm a negative effect of income on religiosity in cross-country analyses. Similarly, Lipford and Tollison (2003) find a negative effect of income on church membership using U.S. state-level data. Becker and Woessmann (2013) study the two-way interplay between church attendance and income in a panel of Prussian counties in 1886–1911 and find that once county fixed effects are controlled for, the link disappears. In contrast to the general pattern in the literature, Franck (2010) finds that the secular politicians who voted in favor of the separation between church and state in France in 1905 were elected in areas with high literacy but lower values on some economic indicators.

church attendance that does not necessarily stem from a causal effect of education.⁶ Recent evidence from modern times underlines such concerns with cross-sectional studies. When exploiting exogenous variation from changes in compulsory schooling laws, [Hungerman \(2014\)](#) finds that education led to a reduction in reported religious affiliation in Canada in post-WW II data. Similarly, recent psychological evidence from randomized laboratory experiments where participants are primed with analytic processing before being asked about their belief in God suggests that analytic thinking promotes religious disbelief ([Gervais and Norenzayan 2012](#)).⁷ However, it is unclear how such modern experience from short-term lab interventions transmits to the analysis of decade-long societal developments during important historical phases of secularization.

The few studies that use panel data models to study the relationship between education and church attendance are either based on recent micro data for individual countries or on cross-country data from the twentieth century. [Brown and Taylor \(2007\)](#) find a positive association between education and church attendance in fixed effect panel regressions based on individual-level data from the British National Child Development Study. By contrast, applying fixed effects regressions to individual-level data from the U.S. Monitoring the Future survey, [Arias-Vazquez \(2012\)](#) finds that education has a negative effect on religiosity at the individual level.

Most closely related to our work in terms of a long-run view is the study by [Franck and Iannaccone \(2014\)](#) who construct a cross-country panel data set for 10 countries over the period 1925–1990 to identify determinants of church attendance. Using fixed effects estimation, most of their specifications do not indicate a statistically significant effect of educational attainment on church attendance. But government spending on education has a consistent negative effect on church attendance in their models, which may indicate a particular role for how governments shape the content of schooling.

To our knowledge, our analysis is the first to take a within-country regional view over an historical period of several decades. Our analysis complements the studies based on cross-country data and on modern-day individual-level data by going back to a crucial period of secularization in a core European country during which church attendance decreased long before official church membership figures declined. Observing this social phenomenon over various decades goes beyond what modern setups can possibly capture. Compared to cross-country analyses, our sub-national analysis of regional variation within a country stays within a given set of national institutions within a limited geographic area and thereby largely conditions out institutional and geographical variation that is harder to control for in cross-country regressions.

3 Institutional background: Germany around the turn to the twentieth century

This section provides some historical and institutional background on Germany around the turn to the twentieth century. It documents the dramatic decline in church attendance in the

⁶ There may also be bias from reverse causality; e.g., [Meyersson \(2014\)](#) provides evidence that religion—specifically, Islamic party rule—affects female education, using a regression-discontinuity design that compares Turkish municipal elections which an Islamic party barely won or lost.

⁷ [Sander \(2002\)](#) and [Brown and Taylor \(2007\)](#) are other notable exceptions which explicitly address concerns of endogeneity, although it is not clear to what extent their use of parental education (and, in the latter case, school characteristics and ability measures) as instruments for education can solve the indicated omitted-variable problems.

context and provides details on the system of advanced schools in Germany during our period of interest.

3.1 A crucial phase of secularization

During the nineteenth and early twentieth centuries, Western Europe underwent a profound process of secularization (see [McLeod 2000](#)). While the very concept of secularization has been questioned for the United States (e.g., [Finke and Stark 1992](#)), it is generally accepted that key indicators of secularization, in particular reduced church attendance, have been “dramatically increasing” in Western Europe ([Berger 1996](#)).⁸ For instance, [Becker and Woessmann \(2013\)](#) find that church attendance fell by 3.6% points per decade, on average, across Prussian counties between 1850 and 1931. [Froese and Pfaff \(2005\)](#) document similar trends for selected regional Protestant churches (*Landeskirchen*) in East Germany between 1862 and 1939.

Our own data (see Sect. 4 below for details) also document a strong process of secularization during our period of study in Germany. For our sample of 61 German cities over the period 1890–1930, panel estimates with city fixed effects reveal a statistically highly significant average decrease in our measure of church attendance of Protestants by about 2% points per decade.

The period and location we study is therefore of chief interest when analyzing the determinants of the process of secularization. In fact, the very religious census that our analysis draws on was established mainly to analyze the “decay” in religiosity in Germany ([Hölscher 2005](#)), indicating a process of secularization observed by the clergy. This is also confirmed in [Hölscher \(2001\)](#), who locates the process from the late eighteenth century onwards.⁹ [Nipperdey \(1988\)](#) supports the existence of this process and points to a large decline in church attendance between 1870 and 1912. As the Protestant Church in Germany gives considerable weight to the institutionalized church as a community of believers, declining religious participation has important bearing for the role of the institutionalized church in general.

3.2 The system of advanced schools

Before World War I, the school system in Germany had three distinct tracks (see [Konrad 2012](#); [van Ackeren et al. 2015](#)). The lowest of the three tracks, elementary schools or “people’s schools” (*Volksschulen*), ran for 8 years, from age 6 to 14. Middle schools (*Mittelschulen* or *Realschulen*), the middle track, ran for 9 years, from age 6 to 15, with the first three school years designated as preparatory classes (*Vorklassen*). The highest track are advanced schools (*Höhere Unterrichtsanstalten*), which ran for 12 years, for students aged 6–18, again with the first 3 years designated as preparatory classes. The system did, in principle, allow transitions between the three tracks, but they were very rare. The three tracks had a clear tendency to follow a class division where working-class children would generally attend people’s schools, white-collar children middle schools, and upper-class children advanced schools. The advanced schools were restricted to male students, whereas the separate advanced school type for female students (*Höhere Mädchenschulen*) had a different focus.

⁸ [Franck and Iannaccone \(2014\)](#) show that the process of declining church attendance continued, albeit at a slower pace, in several Western countries over the period 1925–1990.

⁹ [Hölscher \(2005\)](#) reports that since the mid-eighteenth century, it became unusual to punish people’s absence from church, hence changing it from a duty to a convention. As we focus on a time period after this substantial change in social pressure, our results are unlikely to be influenced by this anymore, adding credibility to our estimates.

The focus of our analysis is on the advanced schools. Variation in enrollment in advanced schools seems particularly relevant to test the traditional view of education and secularization, because advanced schools are most likely to convey the kind of scientific thinking stressed by secularization hypotheses. The focus also reflects the fact that enrollment at the elementary level was as good as universal in Germany throughout our period of observation, in particular in Protestant regions (Becker and Woessmann 2009). Compulsory schooling covered ages 6–14. By the 1880s, enrollment reached 100%, at least in Prussia (Kuhlemann 1991), so there is little if any variation in enrollment in the two lower tracks.

There were three distinct types of advanced schools. The first type, the *humanistisches Gymnasium*, had a humanistic curriculum that focused on classical languages and literature (Latin and Greek). In particular with the advent of large chemical and electronic enterprises during the second phase of industrialization in Germany, demand for two alternative types of advanced schools emerged rapidly. The curriculum of the second type, *Realgymnasium*, focused on modern foreign languages (in particular English) instead of Greek. The third school type, *Oberrealschulen*, had a curriculum with a strong focus on natural sciences and did not include the classical languages. We will use the distinction between the three advanced school types to test whether a particular focus of the curriculum on natural sciences has separate effects on religious participation.

Changes in advanced-school enrollment may affect secularization by exposing more students to material that challenges religious views. However, educational content as such may also change. Indeed, our period of analysis is characterized by two changes that are relevant for the interpretation of our findings. First, in many cities church-run schools were turned into city-run schools. We control for this in our regressions. Second, there were some reforms to the curriculum taught at advanced schools. In Germany's federal structure, curricula are set at the state level, but making up about half of the German Empire, Prussia generally took the lead in setting standards. The Prussian school curriculum of 1882 has the subject "nature observation," where observation suggests a descriptive character of what is being taught (Prussian Ministry of Education 1882, p.28/29). In 1892, "elements of chemistry and mineralogy" is added to the curriculum (Prussian Ministry of Education 1892, p.10), and in 1901, "nature observation" is replaced by "science of nature," pointing to a more analytic character of the teaching content (Prussian Ministry of Education 1913, p.7). In 1907, biology is added to the curriculum as an option (see Prussian Ministry of Education 1913, p.119).

The impact of the new teaching in advanced schools is likely to reach beyond the students taught in the schools themselves. Anecdotal evidence for this comes from the debate about the role of Darwin's theory in advanced school teaching, which was a matter of debate in the Prussian House of Commons (*Preussisches Abgeordnetenhaus*). The debate evolved around Hermann Müller, who taught at an advanced school in Lippstadt and covered evolutionary topics in class as early as 1876, which drew the anger of conservative circles. In a parliamentary debate in January 1879, the conservative MP Baron Wilhelm von Hammerstein argued that "in our fatherland, we see a generation growing up whose belief is atheism ...". He declared that references to evolutionary theories are "a travesty of the gospel" and that the "theories and unproven [...] hypotheses expressed in the works of [...] Darwin [...] do not belong into the classroom of the advanced schools" (cited from Dankmeier (2007), pp. 59–60). This suggests that students seem indeed to have been increasingly exposed to critical thinking and scientific material that challenged established religious beliefs and that the impact extended into a larger societal debate.

4 Data

We construct a unique new panel dataset of German cities between 1890 and 1930 that covers measures of both education and church attendance (see Appendix for details).

First, we digitized data on the enrollment in and number of advanced schools (*Höhere Unterrichts-Anstalten*) from different volumes of the Statistical Yearbooks of German Cities from Neeffe (1892) through *Deutscher Städtetag* (1931).¹⁰ Covering all German cities with a population over 50,000 inhabitants, these yearbooks regularly report the number of students enrolled in advanced schools. Where available, we also digitized the enrollment and school data for each of the separate types of advanced schools (see above).

Our main measure of the enrollment rate in advanced schools is the number of male and female students enrolled in advanced schools as a share of the city population. Although the number of students who are actually enrolled does not constitute a large part of the Protestant population of a city, the structure of the school system is indicative of a city's educational orientation as parents arguably decide upon investment in the children's education. In our view, this measure hence best reflects the overall educational and scientific orientation of the city.¹¹

The yearbooks provide us with data for an unbalanced panel of a total of 61 German cities observed over eight waves that cover every 5 years from 1890 to 1930 (with the exceptions that, due to the interruptions of World War I, there are no data for 1920 and values for 1913 are used instead of 1915). Figure 1 shows that the included cities cover all parts of modern-day Germany.

Apart from the education data, the yearbooks also provide us with data to capture the two aspects of economic development discussed above, income and urbanization. Thus, the yearbooks report data on municipal tax per capita, which we use as a proxy for income. In addition, they provide data on the total population of the city, which captures different degrees of urbanization. In robustness analyses, we extend the analysis to two additional proxies for income, the city-level income tax reported in two volumes of the statistical yearbooks as well as Silbergleit (1908), and teacher income collected in education censuses and provided in different volumes of the *Preussische Statistik*.

We match these data with unique data on church attendance of Protestants. This exceptional database stems from the practice of the Protestant Church to count the number of participations in Holy Communion every year.¹² At the time, church membership was close

¹⁰ We are not aware of a source where data on advanced-school enrollment and tax revenues are consistently available for 1890–1930 at the city or county level other than this source for large cities. While we had no time-varying data on education in the county-level analysis of income and secularization (Becker and Woessmann 2013), the new city-level education data allow a city-level analysis here.

¹¹ Results are similar when using the size of the population aged below 20 (rather than the total population), available in a subsample, as the numerator (Table 3, column 2). Results are also robust to controlling for cities' age structure as a potential influence (Table 3, column 1; see Azzi and Ehrenberg 1975).

¹² Since the norm was to participate in Holy Communion only once per year (Hölscher 2001, p. 37), changes in the opportunity cost of participation are unlikely to drive changes in this measure, in contrast to measures of weekly church attendance. Direct evidence about the norm of one participation in Holy Communion per year comes from analysis of specific records (*Kommunikantenregister*) from the parish church *Kreuzkirche* of Hanover which recorded participation in Holy Communion by name, revealing which individual church members attended Holy Communion at all and at what frequency. Analyzing the time period 1876–1878, Hölscher and Männich-Polenz (1990) find that only 36% of members attended Holy Communion at all (see their Table 8). Of those who do attend Holy Communion at least once in each individual year, more than 98% do so exactly once, and less than 2% attend twice or more (see their Table 7). Those attending more than once are members of the parish council for whom the parish council ordinance of 1864 stipulated a regular and frequent participation in Holy Communion.

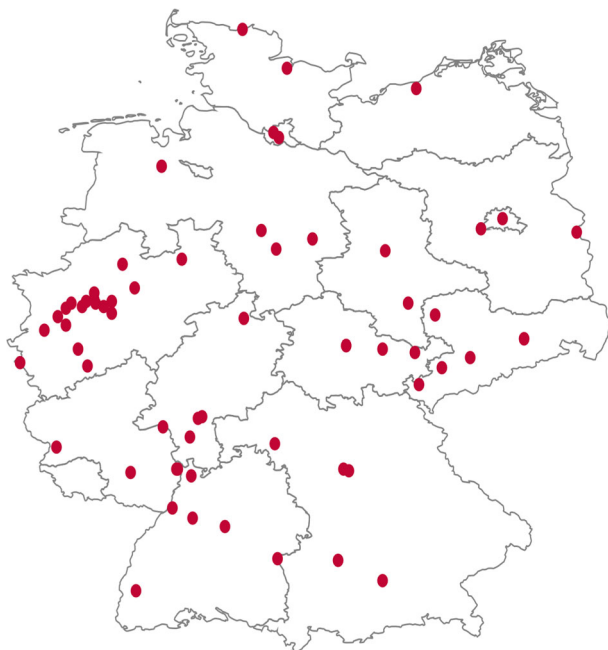


Fig. 1 German cities included in the analysis. Map of modern-day Germany showing the 61 cities with data in the Statistical Yearbooks of German Cities during 1890–1930

to 100% and hardly reveals information about actual religious involvement. In contrast, data on participation in Holy Communion reflects “demonstrations of churchly life ... that were considered already by contemporaries as indicators of churchliness” (Hölscher 2001, p. 4).¹³ As the communion data are based on direct head counts, they also do not suffer from the usual unreliability of survey data on church attendance (Hadaway et al. 1998; Woodberry 1998).¹⁴

Hölscher (2001) gathered the historical Sacrament Statistics for the modern-day German territory from regional archives, providing data on church attendance as measured by the number of participations in communion divided by the Protestant population (see also Becker and Woessmann 2013). The communion data are available at the level of church districts, which we match to our city database.¹⁵ Given that advanced schools draw their enrollment both from the city itself and from the surrounding countryside, the availability of the communion data at the church district level (and of the education data only for larger cities) provides a

¹³ Hölscher (2005) reports that religious behavior in Germany in the nineteenth century mainly involved publically visible actions like church attendance.

¹⁴ Actual data on church attendance collected at specific Count Sundays, available only in a few Regional Churches, indicate a largely parallel movement of church attendance and sacrament participation both in the cross-section and in the time-series (Hölscher 2001, pp. 37–38).

¹⁵ There are three cases where two cities belong to the same church district in our data: Oberhausen and Duisburg; Gladbach-Rheydt and Krefeld-Uerdingen; and Herne and Gelsenkirchen. Throughout, the unit of analysis is cities, of which there are up to 61. As these are contained in 58 church districts, we allow for clustering of standard errors at the level of the 58 church districts.

Table 1 Descriptive statistics. *Data sources* church attendance: [Hölscher \(2001\)](#) based on Sacrament Statistics; other variables: Statistical Yearbooks of German Cities ([Neefe 1892](#) through [Deutscher Städtetag 1931](#))

	Full sample		Estimation sample		
	Mean (1)	Observations (2)	Mean (3)	Minimum (4)	Maximum (5)
Church attendance	0.258 (0.154)	386	0.246 (0.140)	0.049	0.738
Enrollment rate in advanced schools	0.023 (0.008)	443	0.023 (0.009)	0.006	0.050
Municipal tax per capita	33.405 (13.145)	436	32.950 (12.712)	10.747	75.889
Population (in millions)	0.208 (0.347)	522	0.247 (0.433)	0.053	4.337
Share of Protestants (1910)	0.637 (0.293)	514	0.613 (0.286)	0.077	0.968
Prussia	0.625 (0.485)	522	0.601 (0.490)	0	1
Observations			291	291	291

Sample means. SD in parentheses. Full sample denotes the entire original dataset. Estimation sample denotes the dataset that is used in the baseline regressions. Church attendance refers to participations in Holy Communion over Protestants. Enrollment rate in advanced schools refers to enrolled students over city population

reasonable match.¹⁶ Throughout, standard errors in all regressions are clustered at the level of church districts. Also, while the church attendance measure refers to Protestants only, educational enrollment refers to the whole city population; models in subsamples of cities with a mostly Protestant population confirm that this is not driving the results (see columns 5–8 of Table 10 in the Appendix).

The number of cities with complete available data for our analysis from both sources increases from 25 in 1890 to 51 in 1930. In total, there are 291 city-year observations over the eight waves in our unbalanced panel.¹⁷ To compare city characteristics of the initial dataset of up to 522 city-year observations with our estimation sample, Table 1 shows descriptive statistics for both datasets. None of the differences is statistically significant. In the estimation sample, average church attendance is 25%, ranging from 5 to 74%.

In our basic analyses, we report results both for the eight waves of the full period (1890–1930) and separately for the six waves of the period before World War I (1890–1913). We have more confidence in the restricted pre-WW I analysis because WW I has repeatedly been reported to have changed religious beliefs dramatically. For example, [Hölscher \(2001\)](#) reports that society's trust in the clergy collapsed after WW I throughout Germany. In addition, the fact that the post-WW I period is limited to two waves of data (1925 and 1930, with no data for 1920) precludes extensive analyses in this sub-period, in particular in specifications with lags. Furthermore, several of the additional data sources used in robustness analyses are available only for the pre-WW I period. For many of our robustness analyses, we therefore focus on the pre-WW I sample.

¹⁶ Results are robust in subsamples where the city size coincides closely with the size of the church district (Table 10, column 3).

¹⁷ Results are qualitatively the same when the sample is restricted to the initially observed 25 cities (Table 10, column 1). For 32 observations, church attendance values were imputed from neighboring years by linear interpolation (see Appendix). Results are also robust when dropping these observations (Table 10, column 2).

5 Empirical model

The panel setup of our database allows us to estimate panel models with fixed effects that identify the effect of education on religious participation only from within-city variation over time. Such models avoid identification from unobserved time-invariant regional characteristics that may be correlated with both education and church attendance. Specifically, we estimate the following equation:

$$y_{it} = \mu_i + \mu_t + \gamma s_{it} + \beta x_{it} + \varepsilon_{it}$$

where y_{it} denotes participations in Holy Communion per Protestant population, μ_i and μ_t denote fixed effects for city (i) and time (t), respectively, s_{it} is advanced-school enrollment per city population, x_{it} is a set of covariates, and ε_{it} is an error term.¹⁸ Our parameter of interest is γ . In the baseline fixed effects specification, the covariates include municipal tax revenues (a proxy for income) and city population (a proxy for urbanization). In a pooled OLS specification that replicates the cross-sectional nature of existing studies, the city fixed effects are replaced by a dummy that indicates whether the city ever belonged to Prussia and the share of Protestants (in 1910, the only year for which this highly stable measure is available at the city level).

The panel fixed effects specification addresses several concerns with identification in cross-sectional models. The inclusion of city fixed effects addresses potential omitted variable bias that may arise from unobserved time-invariant city characteristics. The inclusion of time fixed effects addresses potential bias from nation-wide common trends in the variables of interest. The remaining question is whether such identification from city-specific variation over time can be given a causal interpretation. Our main analysis does not directly model exogenous variation and hence cannot unequivocally claim causal inference. The identifying assumption of the panel fixed effects model is that the change in the dependent variable would be similar across cities in the absence of differential changes in the included explanatory variables. As in most econometric analyses of this kind, the main remaining concerns relate to potential biases from reverse causality, omitted variables, and attenuation due to measurement error. We briefly introduce these concerns here and come back to them in separate sections below where we discuss in greater detail the remaining issues and how the analyses address them.

In principle, reverse causality from religiosity towards decisions about educational investments might still bias the fixed effects models. For example, strong belief in Protestant teaching may increase demand for education (Becker and Woessmann 2009), or religious people may have more children which—through a trade-off between fertility and education—could reduce investment in children's education (Becker et al. 2010; de la Croix and Delavallade 2015). However, in detailed analyses with different lag structures of the education variable in Sect. 7.1, we show that the time pattern of the effects is consistent with an effect from education on religious participation that materializes over time, whereas there is no evidence of lagged effects of religious participation on education. In addition, in Sect. 7.2 we show that results are robust in dynamic panel models that include the lagged dependent variable, indicating that persistence in church attendance over time is not driving the results. Furthermore, we show that results are robust to the inclusion of city-specific linear time trends, indicating that they do not reflect differential long-term trends in church attendance of cities that may occur for other reasons.

¹⁸ The specification restricts the effect of advanced-school enrollment on religious participation to be the same across cities. The limited time-series variation of our data prevents using more flexible panel time-series models such as used in Herzer and Strulik (2016) in the context of the religious transition of the twentieth century.

Additional remaining bias could come from omitted variables whose city-specific change over time correlates with changes in the two variables of interest. For example, systematic changes in the composition of a city's population would not be captured in the fixed effects. Therefore, in Sect. 6.2 we provide a series of robustness specifications that control for contemporaneous changes in other observed factors. In particular, the additional measures include changes in the demographic composition of the city (age structure, gender structure, and recent migration), changes in the educational environment (opening of universities and emergence of secular schools), changes in the economic environment (industry structure and welfare expenditure), and changes in the political environment (emergence of secular movements and nationalistic sentiment). Furthermore, to avoid identification from potentially endogenous demand-side enrollment decisions and to restrict the analysis to changes in the supply of advanced schools, in Sect. 8 we introduce an instrumental-variable model that uses only variation in advanced-school enrollment that originates from changes in the number of advanced schools in a city.

Finally, in our historical data, measurement error in the independent variables is also likely to attenuate coefficient estimates towards zero. It should be kept in mind throughout that in this sense our estimates are, if anything, conservative.

6 Basic results

We start by describing results based on pooled OLS and fixed effects regressions in this section. In Sects. 7 and 8, we look at dynamic panel data models and instrumental-variables regressions, respectively. While in most of our analysis, we use enrollment in all advanced school types combined, in Sect. 9 we use enrollment in different specific advanced school types to analyze potential mechanisms of the main effect.

6.1 Main results

Using the cross-sectional dimension of our data, columns 1 and 2 of Table 2 replicate the common finding from the literature that education is significantly positively associated with church attendance in the cross-section, both in the full 1890–1930 period and before World War I. In the pooled OLS estimation with year fixed effects, an advanced-school enrollment rate that is higher by one SD is associated with 4% points (or 0.26 SD) higher church attendance in 1890–1930.¹⁹ This positive association is easily visible in a simple scatterplot depicted in panel (a) of Fig. 2 for the example of the year 1900.

When using only within-city variation over time in our baseline panel model with city and year fixed effects, however, this result is turned around (columns 3–4). Increases in education are now significantly negatively related to changes in church attendance.²⁰ This pattern is in line with the traditional view that education leads to secularization. In the panel fixed effects estimation, an increase in the advanced-school enrollment rate by one SD is related to a

¹⁹ These pooled OLS estimation with year fixed effects are qualitatively the same as the between estimator of a fixed effects panel model. Furthermore, when estimating the cross-sectional model separately for each wave, the coefficient on advanced-school enrollment is positive in all eight waves and reaches statistical significance in five of them (not shown).

²⁰ We understand our education measure—the number of advanced-school students as a share of the total city population—as an indicator of the inclination of families towards advanced education. Due to diverse obstacles to actual enrollment such as school fees, this number is likely a truncated measure of the latent propensity to enroll.

Table 2 Education and church attendance: panel estimates for German cities, 1890–1930. *Data sources* church attendance: [Hölscher \(2001\)](#) based on Sacrament Statistics; other variables: Statistical Yearbooks of German Cities ([Neeffe 1892](#) through [Deutscher Städtetag 1931](#))

Estimation method	Pooled OLS		Fixed effects		First difference	
Sample period	Full (1)	Pre-WW I (2)	Full (3)	Pre-WW I (4)	Full (5)	Pre-WW I (6)
Enrollment rate in advanced schools	4.508*** (1.483)	6.494*** (1.860)	−1.620*** (0.534)	−1.866* (0.936)	−2.598 (2.654)	−4.800** (2.183)
Municipal tax per capita	−0.002* (0.001)	−0.008*** (0.003)	0.00005 (0.0003)	0.0009 (0.0009)	0.0004 (0.0012)	0.0023* (0.0012)
Population (in millions)	−0.016 (0.017)	−0.004 (0.023)	0.009 (0.011)	0.076 (0.056)	0.005 (0.014)	0.068 (0.081)
Share of Protestants (1910)	−0.129* (0.068)	−0.113 (0.069)				
Prussia	−0.076** (0.034)	−0.087** (0.035)				
Year fixed effects	Yes	Yes	Yes	Yes	No	No
City fixed effects	No	No	Yes	Yes	No	No
Observations	291	190	291	190	20	20
Clusters	58	47	58	47	20	20
R ² (in FE: within)	0.318	0.404	0.493	0.507	0.083	0.415

Dependent variable: church attendance (participations in Holy Communion over Protestants). Unbalanced panel of 61 German cities with over 50,000 inhabitants observed in eight waves that cover every 5 years from 1890 to 1930 (no data for 1920; 1913 instead of 1915). In columns 5 and 6, all variables refer to the change between starting point and end point of the period. Enrollment rate in advanced schools refers to enrolled students over city population. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

decrease in church attendance by roughly 1.5% points (or 0.10 SD), in both the full and the pre-WW I sample.²¹ This negative association between changes in education and in church attendance is again easily visible in the scatterplot, depicted in panel (b) of Fig. 2 for the pre-WW I period.

To put the magnitude in perspective, consider the 24 cities observed both in 1890 and in 1913: if, rather than their actual mean change in education, they would have only had the change in education of the city at the 10th percentile, the reduction in church attendance would have been 1.3% points smaller. This would account for about one quarter of the actual mean reduction in church attendance of 4.6% points.

The change in the sign of the estimated effect between the cross-sectional and the fixed effects model is consistent with the presence of unobserved time-invariant city-specific characteristics that give rise to a positive correlation in cross-sectional regressions. For instance, a city's population may have historically been of more conservative attitude, putting a stronger emphasis on educational attainment as well as on institutionalized religiosity—hence the

²¹ The estimate for the post-WW I period (not shown) is only about half as large (in absolute terms) and does not reach statistical significance. The within-city variation explained by the regressors drops by nearly half in the post-WW I model, possibly reflecting the large disturbances in society due to the war (see above). However, the weaker finding in the post-WW I sample might also reflect that this sample includes only two waves of data.

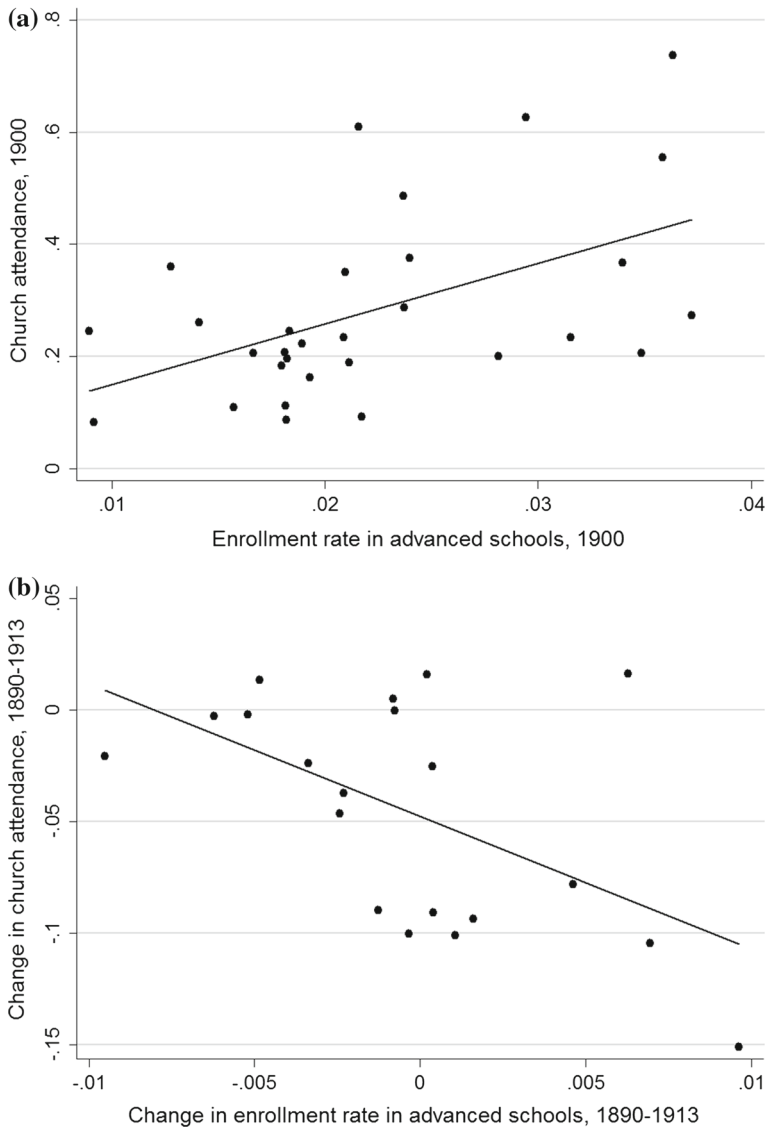


Fig. 2 Education and church attendance: levels and changes. Scatterplots of church attendance against enrollment rate in advanced schools for German cities, **a** 1900 levels and **b** 1890–1913 changes. Church attendance refers to participations in Holy Communion over Protestants. Enrollment rate in advanced schools refers to enrolled students over city population. Data sources: church attendance: [Hölscher \(2001\)](#) based on Sacrament Statistics; enrollment rate in advanced schools: Statistical Yearbooks of German Cities ([Neefe 1892](#) through [Deutscher Städtetag 1931](#))

initial positive correlation. However, with an increase in advanced-school enrollment, also these cities witnessed a drop in church attendance over time.²²

²² While it is difficult to say what exactly the city fixed effects capture—after all, they may mostly reflect differences in dimensions that are unobservable in any data—it may be informative to analyze how the pooled

Interestingly, while education yields sizeable and significant estimates in our models, the same is not true for the other measures of modernization. In the baseline specification, we use municipal tax revenue as a proxy for income. The insignificant and positive point estimate for its coefficient casts doubt on the hypothesis that income adversely affected religiosity. This is in line with [Becker and Woessmann \(2013\)](#) who find that, once fixed effects are included, there is no significant effect of income on religious participation. Similarly, the size of the city population as a proxy of urbanization is not significantly related to church attendance. In Sect. 6.4 below, we will get back to the topic of income and religious participation with additional analysis and discussion.

While the panel models with city fixed effects are identified from the 5-year variations within each city, the main result of a negative association between education and church attendance is also visible in long-run changes. For this, columns 5 and 6 report first-differenced models that regress the change in church attendance from 1890 to 1913/1930 on the change in the explanatory variables over the same time periods. Although based on small samples, the first-differenced models confirm the panel fixed effects models, showing that the long-run changes are consistent with the results of the fixed effects models.

6.2 Robustness to contemporaneous changes in other observed factors

While the fixed effects models take care of any time-invariant characteristics that may differ across cities, the main remaining concern is that other factors may change over time in a way related to both education and church attendance. In general, our period of observation was a period of substantial socio-demographic, economic, and political change, and any city-specific incidence of such changes may interfere with our panel analysis. As a first step to address this concern, in a series of robustness specifications we add a number of potentially confounding variables that we observe over time. These potentially confounding variables include age, gender, migration, opening of new universities, emergence of secular schools, industry structure, welfare expenditure, emergence of secular movements, and nationalistic sentiment.

A factor often argued to be relevant for religious participation is the age of a person (e.g., [Azzi and Ehrenberg 1975](#)). To control for this potential influence, the first column of Table 3 includes measures of a city's age structure, namely the shares of under-20-year-olds and of over-60-year-olds. Despite being available only for the census years 1890 and 1910, results in a sample of 66 observations leave the effect of education qualitatively unchanged and even larger.²³ Both age measures have the expected sign but are statistically insignificant.

While conceptually, the share of advanced-school students in the entire city population is our preferred indicator of a city's educational and scientific orientation, in this smaller sample we can also calculate the enrollment rate as a fraction of under-20-year-olds. Using

Footnote 22 continued

OLS estimates are affected by adding different sets of observed control variables (not shown). Including the different measures of demographic structure, further education, and political preferences used in our robustness analyses in Sect. 6.2 below does not substantially affect the coefficient estimate on advanced-school enrollment in the pooled OLS model. However, controlling for the share of workers in industry and services turns the coefficient on advanced-school enrollment negative, albeit statistically insignificantly so. While the limited availability of data on these control variables leaves this analysis highly explorative, it may suggest that the city fixed effects at least partly capture persistent differences in industry structure across cities.

²³ The specifications with age measures include a dummy for Kassel in 1890, an outlier in these specifications.

Table 3 Robustness to changes in age, gender, migration, universities, and secular schools. *Data sources* church attendance: [Hölscher \(2001\)](#) based on Sacrament Statistics; demographic and school variables: Statistical Yearbooks of German Cities ([Neefe 1892](#) through [Deutscher Städtetag 1931](#)); university data: [Eulenburg \(1904\)](#) and Statistical Yearbook of the German Reich

Enrollment rate	Per city population	Per under-20-year-olds	Per city population			
	(1)	(2)	(3)	(4)	(5)	(6)
Enrollment rate in advanced schools	−4.191* (2.167)	−1.837** (0.856)	−1.671** (0.767)	−1.164** (0.560)	−1.612*** (0.532)	−3.226** (1.303)
Municipal tax per capita	0.001 (0.001)	0.001 (0.001)	−0.0001 (0.0004)	−0.00006 (0.0003)	0.00002 (0.0003)	0.0016 (0.0017)
Population (in millions)	0.053 (0.060)	0.043 (0.060)	0.011 (0.012)	0.009 (0.011)	0.009 (0.011)	−0.023 (0.064)
Share under 20 year olds	−0.160 (0.473)	−0.422 (0.432)				
Share over 60 year olds	1.349 (0.957)	1.275 (0.946)				
Share female			0.161 (0.246)			
Share new citizens				−0.009 (0.087)		
Foundation of university					0.014 (0.012)	
Enrollment rate in universities					0.093 (1.304)	
Share of Protestant advanced schools						−0.044 (0.034)
City and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	66	66	193	257	291	73
Clusters	41	41	54	57	58	33
R ² (within)	0.673	0.684	0.492	0.465	0.494	0.368

Dependent variable: church attendance (participations in Holy Communion over Protestants). Unbalanced panel of 61 German cities with over 50,000 inhabitants observed in eight waves that cover every 5 years from 1890 to 1930 (no data for 1920; 1913 instead of 1915). Columns 1 and 2: waves 1890 and 1910; both columns include a dummy for Kassel in 1890, an outlier. Column 6: waves 1890, 1895, and 1905. Enrollment rate in advanced schools refers to enrolled students over city population; in column 2, it refers to enrolled students over city population aged below 20 years. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

this variable leaves the significant negative coefficient on education unaffected, indicating that our results are robust to this change in the measure of education (column 2).²⁴

Traditionally, women participated more regularly in church activities, possibly because of lower opportunity costs ([Azzi and Ehrenberg 1975](#)). When including the share of females in the model, our result remains robust and the female share is insignificant (column 3).

²⁴ Because the within-variation of the share of under-20-year-olds in a city is small (SD of 0.01 vs. 0.05 between), we conducted the same exercise using a city's share of under-20-year-olds in 1890 or 1910 for all observations. Hence, for the sake of the argument, we assumed there was no within-variation at all in the share of young people. Both alternative measures yield smaller, but significantly negative estimates.

To account for possible effects of migration on church attendance, we include the share of recently arrived citizens in a city (column 4). The coefficient on the share of new citizens is insignificant and small, and the coefficient on education is qualitatively unaffected.

To ensure that results are not related to foundations of new universities in the cities, column 5 controls for an indicator for openings of new universities, as well as for the share of university students in the city population. Neither enters the model significantly, and the coefficient on the enrollment rate in advanced schools remains qualitatively unaffected.

During our period of observation, some advanced schools changed from being religiously affiliated into non-religious schools.²⁵ To the extent that this entailed a change towards a less religious curriculum, our main effect might capture a change in curriculum and educational content rather than an increase in education per se (e.g., [Franck and Iannaccone 2014](#)). However, when including the share of Protestant advanced schools in a city as an additional control, it does not enter the model significantly and does not qualitatively change our main result (column 6). Similarly, the share of Catholic or secular advanced schools does not enter the model significantly or change our main result (not shown). The same is true for the total number of advanced schools, indicating that our result does not capture an effect of increased supply of advanced schools, but rather a demand-side effect.

At a very general level, a change that took place in Germany around the time of our analysis is the rise of the modern welfare state under Bismarck. While most of the emerging social legislation was national in character and would thus be captured by the year fixed effects included in our models, it is also conceivable that they affected regions with different economic structures differently. To address this point, the first column of Table 4 adds the employment share in industry as a control variable. Unfortunately, the measure of the local industry structure is available for only 51 cities across three waves. Still, our main effect of interest is in fact even larger in this specification, whereas the share of workers in industry does not enter significantly in predicting church attendance. The same is true for the share of workers in services, which is added in column 2. Alternatively, when we combine industry and services to control for the employment share in modern (non-agricultural) sectors in one variable (column 3), qualitative results are also effectively the same. Thus, our results do not seem to be driven by changes in industry structure as a potentially confounding development.

To directly address potential city-specific differences in the introduction of welfare measures, column 4 adds a city-level measure of social welfare spending, namely public per-capita expenditures on poor relief, that is widely available across cities and time. Again, city-specific changes in these welfare expenditures do not predict changes in church attendance, and the main result on the effect of education remains qualitatively unaffected. This supports the interpretation that city-specific affectedness or implementation of welfare-state measures are unlikely to be major confounding factors.

Activities in secular associations might have increasingly crowded out participation in church activities during our period of observation. To address this, we use the vote share for social-democratic parties in national elections over time as a proxy for the strength of alternative secular movements. August Bebel, one of the leading figures of social democracy in Germany at the time, famously declared that “Christianity and Socialism are opposing each other like fire and water.”²⁶ Emerging secular movements might have organized activities

²⁵ In our data, the average number of advanced schools hardly changed between 1885 and 1905 (average increase of 0.13 schools per city), but the number of Protestant schools decreased by an average of 0.38 schools, whereas the number of secular schools increased by an average of 0.55 schools (the difference being made up by an average decrease of Catholic schools of 0.05).

²⁶ “Christenthum und Sozialismus stehen sich gegenüber wie Feuer und Wasser” (August Bebel in his controversy with Chaplain Wilhelm Hohoff, published in “Christenthum und Sozialismus”, Berlin 1874).

Table 4 Robustness to changes in industry structure, welfare spending, and political vote shares. *Data sources* church attendance: [Hölscher \(2001\)](#) based on Sacrament Statistics; demographic and welfare variables: Statistical Yearbooks of German Cities ([Neefe 1892](#) through [Deutscher Städtetag 1931](#)); industry data: Preussische Statistik, Vol. 76b (for 1882) and Statistik des Deutschen Reichs (1895) through (1907); vote shares: [Schmädeke \(2001\)](#)

	(1)	(2)	(3)	(4)	(5)	(6)
Enrollment rate in advanced schools	−2.816** (1.158)	−3.076** (1.161)	−2.729** (1.163)	−2.047** (1.006)	−1.864* (0.945)	−1.716* (0.954)
Municipal tax per capita	−0.0009 (0.0016)	−0.0012 (0.0015)	−0.0007 (0.0017)	0.0015** (0.0007)	0.0009 (0.0008)	0.0010 (0.0008)
Population (in millions)	0.008 (0.049)	0.005 (0.047)	0.011 (0.052)	0.056 (0.057)	0.074 (0.057)	0.075 (0.055)
Share of workers in industry	−0.131 (0.088)	−0.146 (0.087)				
Share of workers in services		0.194 (0.338)				
Share of workers in industry and services			−0.084 (0.097)			
Expenditures on poor relief per capita				−0.005 (0.006)		
Share of social-democratic votes					0.009 (0.095)	
Share of votes for nationalistic parties						−0.030 (0.029)
City and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	51	51	51	157	190	190
Clusters	19	19	19	47	47	47
R ² (within)	0.494	0.500	0.487	0.548	0.507	0.514

Dependent variable: church attendance (participations in Holy Communion over Protestants). Unbalanced panel of 61 German cities with over 50,000 inhabitants observed in eight waves that cover every 5 years from 1890 to 1930 (no data for 1920; 1913 instead of 1915). Columns 5 and 6: waves before WW I. Enrollment rate in advanced schools refers to enrolled students over city population. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

in particular on Sundays that would have taken time away for possible church visits, and they might have offered facilities that were traditionally in the realm of the church. To the extent that the social-democratic party organized activities in Sunday and that members of other emerging secular movements were more likely to vote for the social-democratic party, controlling for the social-democratic vote share will capture aspects of the emerging secular movements. In addition, in its founding constitution of 1875, the German social-democratic party explicitly demanded that religion should become a private affair outside the realm of the state. In the extended specification including the social-democratic vote share, results on our main coefficient of interest are unaltered and the vote share for social-democratic parties is itself statistically insignificant (column 5). The same qualitative results are obtained when controlling for the vote share of all left-leaning parties (not shown).

Another possible concern is that the expansion of education might have been used by the state to influence the population to support the emerging nation (e.g., [Lott Jr 1990](#); [Pritchett and Viarengo 2015](#)), which might have antagonized it against religious organizations. While this would most directly relate to primary schools and less to the advanced schools of our

analysis, we address this concern by adding the vote share for nationalistic parties to our model. The nationalistic parties were explicitly singled out by Bismarck as supporting the German state, so that their vote share provides a decent proxy for the formation of a nation-minded population (Cinnirella and Schueler 2016). As is evident from column 6, changes in the share of votes for nationalistic parties are not significantly related to changes in church attendance, and their inclusion does not qualitatively affect our estimate of the relationship between education and church attendance.

6.3 Subsample analyses

Results also prove highly robust in different subsamples. As the first column of Table 10 in the Appendix shows, results are qualitatively unaffected in the sample of the 25 cities that were already observed in 1890 (statistical significance at 11%). Results are also robust when dropping the 32 observations whose church attendance data were imputed by linear interpolation (column 2). We further test the robustness of our results to discrepancies in the number of Protestants between the church district and the city in 1910 (the only year for which both measures are available). In a subsample of cities whose size was close to that of the church district, the education coefficient remains qualitatively unchanged (column 3).

Over time, new advanced schools may have been set up in medium-sized cities in the neighborhood of the large cities included in our sample, pulling students from medium-city cities out of advanced schools in the large cities where they had previously attended.²⁷ To test that results are not driven by such changes, we exclude all cities situated in urban regions, restricting the analysis to only those cities situated in rural regions or regions with rudiments of suburbanization (*Regionen mit Verstdterungsanstzen*).²⁸ Our results hold in this subsample (column 4).

When we split the sample along the share of Protestants in the city in the census year 1910 (columns 5–8), we find that the result is largely the same in cities with a Protestant majority and minority. In cities that are overwhelmingly Protestant, the coefficient is still negative and large, but loses statistical significance. This may reflect the reduced sample size, but it may also indicate that determinants of demand decreases like education play a lesser role in cities with a very large Protestant share because social pressure motives make it more common that people attend church as an investment in social capital (Hlscher 2005).

Results are also robust to a number of additional robustness checks not shown in the table. First, they are robust to dropping Berlin, by far the largest city in the sample. Second, we included dummy variables for structural breaks in municipal borders, such as when smaller neighboring towns were incorporated into Berlin before the 1925 observation and into several cities in the Ruhr area before 1930. Qualitative results are unaffected in this specification. Third, to test that results are not driven by jumps due to measurement error in the data, we included dummy variables for periods whenever particularly large changes occurred in the variable of interest between two points in time, such as upward or downward jumps of 50, 30%, or even only 20%. Results are fully robust, and if anything, point estimates become larger, as would be expected for classical measurement error.

²⁷ This may also explain why the average share of advanced-school students in the total population does not increase on average in our city sample, although it does increase steadily in the German Reich at least since 1895 (Mller 1987). Still, the absolute number of students more than doubled in our city sample from 1890 to 1930.

²⁸ These classifications are based on the modern classification of regions (*Siedlungsstrukturelle Regionstypen*) by the Federal Institute for Research on Building, Urban Affairs and Spatial Development; given the long-run process of urbanization, this restricts the sample even further than would be required by historical standards.

6.4 Different measures of income

Given that income is often a main competing explanatory factor for decreasing church attendance in secularization theories (see Sect. 2.1) and given that income and education are often positively associated, we also focus on the robustness of our results on the effect of education on church attendance to the use of different income measures. The proxy for income included in our baseline model refers to the per-capita municipal tax revenue of cities, available from the same Statistical Yearbooks of German Cities that provide our data on enrollment in advanced schools. While overall municipal taxes proxy for a city's income, they may to some extent also reflect specific local preferences in that, for example, some cities charged a horse tax while others did not.

By contrast, there is one component of municipal taxes, the income tax, that was centrally determined and was directly based on the income of the population. However, city-level data on per-capita revenues from income tax are available only for Prussian cities and only for the period 1890–1905. A third proxy for overall income used previously in [Becker and Woessmann \(2009, 2013\)](#) is the average annual income of male elementary-school teachers. As teacher income was almost entirely financed from local contributions, it likely reflects overall local income, and teaching is a well-defined occupation that facilitates comparison. However, teacher income data are only available at the county (rather than city) level and again are only available for Prussia and only for the period 1890–1910.

As shown in Table 11 in the Appendix, all three income measures are positively associated with enrollment in advanced schools. However, only the two alternative measures capture statistical significance, whereas the original municipal tax measure does not. Furthermore, in this depiction that includes city and year fixed effects so as to reflect the identifying variation of our analysis, changes in both tax-based measures are significantly positively associated with changes in the teacher income measure (although not among each other), corroborating the interpretation that each proxies for income.²⁹

In our baseline model, municipal income tax per capita consistently enters insignificantly in predicting church attendance. To test whether the specifics of this measure drive our insignificant results on income, columns 2 and 3 of Table 5 show results when instead using the two alternative income measures. Both income tax per capita and teacher income enter the model statistically insignificantly and negatively. Despite the smaller samples of available income data, the coefficient on the education measure remains significant and is in fact larger in magnitude than in the baseline model. When including all three income measures together, all three have a negative but insignificant relationship with church attendance (column 4). Even in the absence of the education variable (columns 5–7), neither of the income measure captures statistical significance in predicting church attendance.

In sum, the choice of the income proxy is not driving our results. All income measures are insignificantly related to church attendance in our preferred specification. What is more, irrespective of the income proxy used, the negative effect of education on church attendance is large and highly significant.

In light of the conceptual framework discussed in Sect. 2.1, our results suggest that in our historical context, modernization in the form of higher education was a stronger driver for the decline of church attendance than other aspects of modernization. The Marxian view that improved material conditions lead to lower church attendance is not supported by our city-level analysis (see also [Becker and Woessmann 2013](#)). Also, an opportunity-cost view

²⁹ Without city fixed effects, all three income measures are significantly positively correlated with each other, whereas only the income tax measure is significantly correlated with enrollment in advanced schools.

Table 5 Alternative income measures. *Data sources* church attendance: [Hölscher \(2001\)](#) based on *Sacrament Statistics*; municipal tax per capita, population, and enrollment rate in advanced schools: *Statistical Yearbooks of German Cities (Neefe 1892 through Deutscher Städtetag 1931)*; income tax per capita: *Statistical Yearbooks and Silbergleit (1908)*; teacher income: [Galloway \(2007\)](#)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Enrollment rate in advanced schools	–1.866* (0.936)	–2.928** (1.240)	–2.616* (1.411)	–2.881** (1.238)			
Municipal tax per capita	0.0009 (0.0009)			–0.0014 (0.0013)	0.0010 (0.0008)		
Population (in millions)	0.076 (0.056)	0.024 (0.048)	0.044 (0.054)	0.015 (0.052)	0.103* (0.056)	0.060 (0.045)	0.068 (0.055)
Income tax per capita		–4.039 (5.046)		–2.390 (4.682)		–6.220 (4.997)	
Teacher income (in 1000 Mark)			–0.012 (0.017)	–0.015 (0.018)			–0.022 (0.018)
City and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	190	68	94	68	206	73	104
Clusters	47	19	24	19	51	20	29
R ² (within)	0.507	0.451	0.549	0.486	0.500	0.370	0.502

Dependent variable: church attendance (participations in Holy Communion over Protestants). Unbalanced panel of German cities with over 50,000 inhabitants observed in six waves that cover every 5 years from 1890 to 1915 (1913 instead of 1915). Enrollment rate in advanced schools refers to enrolled students over city population. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

of modernization where larger cities are associated with more temptations to spend a Sunday does not come out in the regression analyses. Instead, increased education matters. We will discuss potential mechanisms by which education affects church attendance in Sect. 9, where we exploit data on different types of advanced schools.

7 Dynamic panel models

The fixed effects panel models so far have only considered contemporaneous effects of education on church attendance. In this section, we turn to dynamic panel models that consider different lags of the education variable, include lagged church attendance, and test for robustness to city-specific trends.

7.1 Different lag structures of education

A first concern is that results so far might suffer from bias due to reverse causality if religious participation affects education decisions. Furthermore, we interpret our measure of education—enrollment in advanced schools—as a measure of the overall educational and scientific orientation of the city as reflected in families’ openness to advanced education. Given this measure, one might expect education to affect religious participation with some time lag. In particular, part of the effect may come from the students who went to advanced schools subsequently deciding to reduce religious participation themselves.

The first two columns of Table 6 add the first lag of enrollment in advanced schools to our baseline model. Both the contemporaneous and the lagged enrollment variable enter the model with negative coefficients, but the coefficient on the lagged variable is about twice as large in absolute terms and is the only one capturing statistical significance. Even more strikingly, when adding the second lag of advanced-school enrollment, both the contemporaneous and the first lag of the education measure are insignificantly different from zero, while the second lag is negative, large, and statistically highly significant (columns 3–4). Alternatively, when including each lag of the education variable separately, both the first and the second lag enter significantly with a coefficient estimate slightly larger than in the contemporaneous baseline model, but the model with the second lag is most precise (columns 5–6). By contrast, the third lag of the education measure (or any further lag) does not capture statistical significance (column 7).

The results of the models with alternative lag structures indicate that increased enrollment in advanced schools is followed by subsequent decreases in church attendance. The fact that the dynamic pattern is strongest after about 10 years (the second lag) is hard to reconcile with an interpretation where the results are mostly driven by reverse causality from church attendance to advanced-school enrollment. Instead, it is most consistent with an interpretation where the effect of advanced education on religious participation materializes over time.

The interpretation is corroborated by the fact that lagged church attendance does not predict subsequent changes in advanced-school enrollment. In a model where the enrollment rate in advanced school is the dependent variable, lagged church attendance does not enter significantly (column 8). This is true for additional lags of church attendance, as well (not shown). That is, while changes in education predict subsequent changes in religious participation in our model, the reverse of changes in religious participation predicting subsequent changes in education is not true.

Table 6 Alternative lag structures. *Data sources:* church attendance: [Hölscher \(2001\)](#) based on Sacrament Statistics; other variables: Statistical Yearbooks of German Cities ([Neefe 1892](#) through [Deutscher Städtetag 1931](#))

<i>Dependent variable</i>	<i>Church attendance</i>			<i>Pre-WW I</i>			<i>Enrollment</i>	
	<i>Full</i>	<i>Pre-WW I</i>	<i>Full</i>	<i>Pre-WW I</i>	<i>Pre-WW I</i>		<i>Pre-WW I</i>	
<i>Sample period:</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Enrollment rate in advanced schools	−0.497 (0.574)	−1.152 (0.958)	−0.074 (0.734)	−1.596 (1.005)				
L1 (enrollment rate)	−0.898* (0.491)	−2.051** (1.017)	0.220 (0.621)	0.451 (0.914)	−1.999* (1.029)			
L2 (enrollment rate)			−1.820*** (0.632)	−2.084*** (0.694)		−2.022*** (0.635)		
L3 (enrollment rate)							−0.425 (1.052)	
L1 (church attendance)								−0.008 (0.015)
Municipal tax per capita	0.0003 (0.0003)	0.0006 (0.0010)	0.0004 (0.0003)	0.0015* (0.0009)	0.0004 (0.0009)	0.0014 (0.0009)	0.0008 (0.0008)	0.00004 (0.00009)
Population (in millions)	0.002 (0.011)	0.051 (0.069)	−0.007 (0.010)	0.0945 (0.107)	0.069 (0.071)	0.119 (0.101)	0.021 (0.120)	−0.017*** (0.005)
City and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	231	142	182	106	144	110	79	156
Clusters	54	42	43	32	42	33	31	48
R ² (within)	0.470	0.548	0.456	0.517	0.522	0.510	0.397	0.147

Dependent variable: columns 1–7: church attendance (participations in Holy Communion over Protestants); column 8: enrollment rate in advanced schools. Unbalanced panel of 61 German cities with over 50,000 inhabitants observed in eight waves that cover every 5 years from 1890 to 1930 (no data for 1920; 1913 instead of 1915). Enrollment rate in advanced schools refers to enrolled students over city population. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

Table 7 Dynamic panel models and city-specific trends. *Data sources* church attendance: Hölscher (2001) based on Sacrament Statistics; other variables: Statistical Yearbooks of German Cities (Neefe 1892 through Deutscher Städtetag 1931)

	(1)	(2)	(3)	(4)	(5)
L1 (church attendance)	0.367*** (0.113)	0.116 (0.116)	0.119 (0.117)	0.114 (0.111)	−0.222** (0.109)
Enrollment rate in advanced schools	−1.591* (0.843)		−1.743 (1.056)	−1.656 (1.128)	−2.733** (1.164)
L1 (enrollment rate)			0.888 (0.960)		
L2 (enrollment rate)		−1.700** (0.755)	−1.832** (0.848)	−1.629* (0.841)	
Municipal tax per capita	0.0006 (0.0009)	0.0012 (0.0009)	0.0014 (0.0009)	0.0013 (0.0009)	0.0003 (0.0011)
Population (in millions)	0.059 (0.060)	0.111 (0.104)	0.094 (0.106)	0.086 (0.101)	0.067 (0.126)
City and year fixed effects	Yes	Yes	Yes	Yes	Yes
City-specific time trends	No	No	No	No	Yes
Observations	150	109	105	106	150
Clusters	46	33	32	32	46
R ² (within)	0.599	0.517	0.525	0.541	0.847

Dependent variable: church attendance (participations in Holy Communion over Protestants). Unbalanced panel of German cities with over 50,000 inhabitants observed in six waves that cover every 5 years from 1890 to 1915 (1913 instead of 1915). Enrollment rate in advanced schools refers to enrolled students over city population. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

7.2 Lagged dependent variable and city-specific trends

A further concern with the panel models presented so far is that religious participation is likely correlated over time. To account for persistence in church attendance, Table 7 presents dynamic panel models with a lagged dependent variable. When added to our baseline model in column 1, current church attendance is indeed significantly positively related to lagged church attendance.³⁰ At the same time, the coefficient on advanced-school enrollment remains significantly negative. The long-run effect of advanced-school enrollment on church attendance implied in this model (the coefficient on enrollment over the difference between one and the coefficient on lagged church attendance) is −2.513, which is even larger than the −1.866 in the static baseline panel model.

Interestingly, when we use the second lag of advanced-school enrollment (rather than current enrollment), lagged church attendance becomes insignificant (column 2). This suggests that the persistence in church attendance really mainly reflects that lagged church attendance is affected by longer lags in (persistent) advanced-school enrollment. As in the model without a lagged dependent variable, only the second lag of education enters significantly when contemporaneous education and two lags of education are entered jointly (column 3). The contemporaneous education variable is also strongly negative but does not reach statistical

³⁰ These dynamic panel models are restricted to the pre-WW I period because the two waves of the post-WW I period do not allow for extensive analysis of lags. Note that the estimates may suffer from Nickell bias; data limitations prevent estimating more elaborate dynamic panel models.

significance at conventional levels (with or without the first lag included, column 4). Overall, results are thus very robust to the inclusion of the lagged dependent variable.

Our panel fixed effects models identify the coefficient of interest from within-city changes in education and church attendance over time. The identifying assumption of these models is that the *change* (rather than level) in church attendance would be similar across cities in the absence of differential changes in advanced-school enrollment (conditional on other observed changes). However, cities may be on different long-term trends in church attendance for other reasons unobserved in the analysis. One way to account for potential bias from different long-term city trends is to add city-specific linear time trends to the model, that is, to interact each city fixed effect with a time trend. Such a specification is very demanding, as it may throw out much of the unbiased identifying variation from the analysis. Still, when we add city-specific trends to the basic dynamic panel model in column 5 of Table 7, the negative coefficient on advanced-school enrollment stays significant and even increases in size.

8 Instrumental-variable estimates

The panel models attempt to purge the coefficient of interest from potential bias from omitted city characteristics by including city fixed effects. However, none of the specifications so far attempts to directly model variation in school enrollment that is arguably exogenous to the error term of our church-attendance model. A main remaining concern is that the identifying variation in school enrollment might be driven by variation in the demand for advanced schools that stems from omitted variables that are also associated with religious participation.

In this section, we propose an instrumental-variable model to identify arguably exogenous variation in advanced-school enrollment. An instrumental variable that can identify variation in advanced-school enrollment that is not driven by individual preferences for advanced schooling is the supply of advanced schools, as measured by the number of advanced schools in a city. In such an instrumental-variable model, only the part of the within-city variation in advanced-school enrollment that stems from the opening and closing of advanced schools is used to identify the effect of advanced schooling on church attendance. The number of advanced schools in a city affects the enrollment rate because a larger number of schools *ceteris paribus* decreases commuting time to school and offers more possibilities to parents to send their children to advanced schools. At the same time, the number of advanced schools should not be related to church attendance in other ways than through the actual enrollment in school, so the exclusion restriction is likely to hold. Note that we keep the fixed effects panel structure of the model, so that results are identified from differential within-city variation in the opening and closing of advanced schools over time.

In the first stage of this instrumental-variable model, the number of advanced schools in a city significantly predicts advanced-school enrollment (Table 8). In column 1, we use the first lags of the number and enrollment in advanced schools, whereas in column 2 we use the second lags; results are quite similar. The partial F statistics of the excluded instrument in the first stage suggest that the instruments are not particularly strong, though.

In the second stage, the point estimate on advanced-school enrollment is slightly larger than and insignificantly different from our baseline model, even though it does not capture statistical significance at conventional levels. To elaborate on these results, we also look at the enrollment rate just in *Gymnasien* and *Realgymnasien*, the more classical institutions of the advanced-school system (see Sect. 3.2), as we discuss in greater detail in the next section. Here, we use the number of *Gymnasien* and *Realgymnasien* as an instrument. The first-stage partial F statistics are slightly larger in this specification (columns 3 and 4), although still not

Table 8 Instrumental-variable estimates. *Data sources*: church attendance: [Hölscher \(2001\)](#) based on Sacrament Statistics; other variables: Statistical Yearbooks of German Cities (Neefe 1892 through [Deutscher Städtetag 1931](#))

	All advanced schools		Only <i>Gymnasium</i> and <i>Realgymnasium</i>	
	Lagged once (L1) (1)	Lagged twice (L2) (2)	Lagged once (L1) (3)	Lagged twice (L2) (4)
<i>Second stage</i>				
Enrollment rate in advanced schools	−3.030 (3.322)	−2.726 (2.715)	−9.635* (5.747)	−9.302* (5.339)
<i>First stage</i>				
Number of advanced schools (in 10,000)	2.613** (1.044)	3.533*** (1.188)	8.707*** (2.838)	8.788*** (3.027)
Municipal tax per capita; Population	Yes	Yes	Yes	Yes
City and year fixed effects	Yes	Yes	Yes	Yes
Observations	128	96	91	96
Clusters	43	33	32	33
1 st -stage <i>F</i> statistic	6.270	8.844	9.410	8.431

Two-stage least squares regressions. Dependent variable in the second stage: church attendance (participations in Holy Communion over Protestants). Dependent variable in the first stage: enrollment rate in advanced schools. Unbalanced panel of German cities with over 50,000 inhabitants observed in six waves that cover every 5 years from 1890 to 1915 (1913 instead of 1915). Enrollment rate in advanced schools refers to enrolled students over city population. All regressions control for municipal tax per capita and population. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

particularly strong. The estimated impacts of advanced-school enrollment in the second state are larger than in our main specification and reach statistical significance at the 10% level.

While statistical precision is limited in these instrumental-variable estimations, in the absence of other instruments that plausibly meet the exclusion restriction we still find these instrumental-variable results interesting and supportive of our findings. Overall, even though the estimates have large standard errors, the point estimates are consistent with and even larger in magnitude than the baseline results, indicating that advanced education reduced church attendance.

9 Explorations into mechanisms: different types of advanced schools

As a final analysis, we explore different potential mechanisms how education may have affected religious participation. While education may have affected economic development which some secularization hypotheses argue to affect secularization (Sect. 2.1), the fact that we do not find evidence for effects of different measures of income and urbanization in our models (Sect. 6.4) casts doubt that this is a particularly relevant mechanism in our context. Similarly, our analysis of robustness to contemporaneous changes in other factors in Sect. 6.2 has shown that the estimated effect of education is hardly affected by conditioning on enrollment at the university level, the sectorial structure of the economy, welfare spending on poor relief, the emergence of secular movements (as measured by social-democratic votes), and nationalistic sentiment (as measured by votes for nationalistic parties). While each of these factors might in principle be conceived as a potential mechanism through which education might have affected religious participation, the results suggest that none of the factors is a major channel of our main result. These results suggest that it might have been the schooling per se that exerted the effect.

As discussed in the conceptual framework (Sect. 2.1), there may be two separate aspects of schooling that might have given rise to reduced church attendance, which we referred to as critical thinking and scientific knowledge. We can use the different curricula of the different types of advanced schools (see Sect. 3.2) for an exploration into which of these two mechanisms may have been particularly relevant. The school type most directly oriented towards scientific knowledge was the newly emerging *Oberrealschule* with its curricular focus on the natural sciences. In these schools, students learn scientific facts that may reduce their belief in religious explanations of natural phenomena. By contrast, the traditional *Gymnasium* had a humanistic curriculum focused on classical languages and literature which may have sparked critical thinking towards the church as an institution in general but instilled only limited knowledge in modern sciences. To a lesser extent, the same can be argued for the *Realgymnasium* with its curricular focus on modern languages.

Table 9 shows estimates of our model separately for each type of advanced schools. The first column indicates that the significant negative effect of total advanced-school enrollment on church attendance is also visible in the subsample of periods for which data on attendance rates are available by type of advanced schools. Column 2 separates out the advanced schools for male students (*Höhere allgemeine Bildungsanstalten für das männliche Geschlecht*) and the advanced schools for female students (*Höhere Mädchenschulen*). The subdivision into different types of advanced schools is only available for the schools for male students. In fact, the *Höhere Mädchenschulen* were neither oriented towards the humanistic education of the *Gymnasien* nor towards the advanced teaching in the natural sciences of the *Oberrealschulen* but were rather attended by the daughters of upper-class families (“höhere” Töchter, see

Table 9 Different types of advanced schools. *Data sources* church attendance: Hölscher (2001) based on Sacrament Statistics; other variables: Statistical Yearbooks of German Cities (Neefe 1892 through Deutscher Städtetag 1931)

Enrollment rate in	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Advanced schools	−2.131*							
	(1.139)							
Advanced schools for male students		−2.815						
		(2.163)						
Advanced schools for female students		−1.371	−1.470	−2.286				
		(1.577)	(1.610)	(1.500)				
<i>Gymnasium</i> (classical languages and literature)			−4.082		−2.864			
			(2.481)		(1.794)			
<i>Realgymnasium</i> (modern languages)			−3.590			−1.946		
			(2.874)			(3.028)		
<i>Oberrealschulen</i> (natural sciences)			−2.837				−2.451	
			(3.456)				(1.620)	
Middle schools (<i>Realschulen</i>)			0.115					
			(3.319)					
Other advanced schools			−1.942					
			(3.218)					
<i>Gymnasium, Realgymnasium, and Oberrealschulen</i>								−3.050**
								(1.546)
City and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	146	146	146	146	146	146	146	146
Clusters	46	46	46	46	46	46	46	46
R^2 (within)	0.492	0.494	0.520	0.473	0.475	0.465	0.478	0.505

Dependent variable: church attendance (participations in Holy Communion over Protestants). Unbalanced panel of German cities with over 50,000 inhabitants observed in five waves that cover every 5 years from 1890 to 1905 plus 1913. All school type measures refer to number of students enrolled in the specific type of advanced school over city population. All regressions control for municipal tax per capita and population. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

Konrad 2012, p. 85). Consistently, the point estimate for female schools is only half as large as for the male schools, although both lack statistical significance when entered jointly. Column 3 jointly enters the enrollment rates in the different types of advanced schools, whereas columns 4–7 show results for each of the main types of advanced schools separately.

While the separate estimates of the different school types are all relatively imprecisely estimated, they all have negative point estimates and fall roughly in the same ballpark, with no clear indication that the effect of one school type is particularly stronger than the other. If anything, the effect seems to be largest in the classical institution of the *Gymnasium* (and possibly the *Realgymnasium* in column 3) which had limited teaching in the natural sciences. As a consequence, it does not seem that the instillation of scientific knowledge is a pivotal aspect for the effect of advanced-school education on church attendance. Rather, the evidence on the *Gymnasien* suggests that a general conveyance of critical thinking in advanced schools may have undermined the willingness to subordinate to the institutionalized church.

This is consistent with the result on enrollment in middle schools (*Realschulen*), which is also included in column 3. The coefficient on middle schools, which ran for nine rather than 12 years and had a practically oriented rather than academic curriculum focused on occupational demands (Konrad 2012, [p. 82]), is small and positive. Finally, when combining enrollment

in the three main types of advanced schools together in column 8, the negative effect is in fact statistically significant and larger than the overall effect, indicating a rather general effect of these advanced schools.

Of course, these results are in no way conclusive, not least given the limited statistical power of the separate estimates. However, they inform the debate about which aspect of education is particularly relevant in decreasing religious participation. Our results side with the explanation that education decreases the belief in the institution of the church, while we find little evidence that the main channel is the learning of scientific facts.

10 Conclusion

Despite extensive academic debates, there is little empirical evidence on the sources of secularization during its crucial phase in European history. To fill this gap in the analysis of the effect of education on secularization, we constructed a unique panel dataset of German cities between 1890 and 1930 that has not been analyzed so far. Starting with cross-sectional regressions, we replicate the finding of many previous studies that education and church attendance are positively correlated. But the finding turns around when city fixed effects control for time-invariant city characteristics. The robustness of the result in several sensitivity analyses, the fact that increases in education precede declines in church attendance but not vice versa, and the findings from models with lagged dependent variables, city-specific trends, and instrumental-variable estimates that use variation stemming from changes in the supply of advanced schools all support a negative effect of education on secularization.

The results suggest that the traditional view of secularization hypotheses that education furthered secularization finds support in our historic setting: Increases in education were closely related to people's reduced active involvement with the institutionalized church and its rituals, one of the most seismic changes in social history since the nineteenth century. Further evidence from enrollment rates in different types of advanced schools is most consistent with a mechanism where advanced-school education increased critical thinking in general which led to the questioning of the institution of the church, whereas there is no strong evidence for a specific effect of the scientific knowledge associated with learning facts of the natural sciences.

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Appendix

Data on enrollment in advanced schools

Our main measure of the enrollment rate in advanced schools is calculated as the number of students enrolled in advanced schools as a share of the city population. Consecutive volumes of the Statistical Yearbooks of German Cities (Neefe 1892 through *Deutscher Städtetag* 1931) report data on enrollment in advanced schools (*Höhere Unterrichts-Anstalten*). The yearbooks cover all German cities with a population of over 50,000 inhabitants, providing data on up to 61 German cities observed over eight waves that cover every 5 years from 1890

to 1930. Exceptions due to the interruptions of World War I are that there are no data for 1920 and that 1913 values are used instead of 1915. When sub-district values of a city are reported, we use the joint value. Where the yearbooks in some cases provide values of adjacent years (while other values in the table are reported for the actual year), we use these values. If data were reported as double years, e.g., 1892/93, we chose the first year of a double year where differences were minor and the available value if the year of interest was only reported once.

When only the number of male students is reported in a given year but both male and female students are reported in adjacent years, we estimate the number of female students in the year of interest by assuming that the relative share of male and female students remained constant relative to the adjacent year (four cases in 1890, one in 1900). If the variation over time was large and values appeared not comparable, we refrained from doing so. Where every measure was missing in 1 year, we took the adjacent year's value. This occurred in the 1895 sample, for which we took the values of the school year 1893/94 (also one case in 1913; two cases in 1895 have values from 1896/97). Where it was not possible to use adjacent years, we used the average relative size of female to male students (one case in 1930). Where outliers were obtained, we refrained from imputing the number of students.

In several waves, enrollment data are reported by school type (e.g., municipal vs. state schools). Where one of the parts was indicated as missing, we treated the entire value as missing. We do not include so-called pre-schools (*Vorschulen*), which are sometimes connected with advanced schools, in our measure. The separation is generally possible for male students, whereas pre-schools are not separately indicated for female students. The relatively low share of students relative to the city population in 1925 is pointed out in the 1927 year-book's introduction and justified by small birth cohorts between 1915 and 1918, during World War I.

Data on church attendance

Our measure of church attendance stems from an exceptional database that “unlocks source material that is internationally unique in its scope and historical depth: the statistical surveys of the Protestant Regional Churches of Germany on the Expressions of Churchly Life” (Hölscher 2001, p. 29). The uniform annual surveys were organized by the Statistical Central Office at the Protestant Higher Church Council in Berlin from 1880 (with precursors) to World War II. Parish priests collected the data on preprinted forms following uniform surveying directives. Regional Consistories combined these parish data into registers at the level of church districts, which usually comprised 10–20 adjacent parishes.

Our main indicator of church attendance is the “sacrament participation” (Hölscher 2001), measured as the number of participations in Holy Communion divided by the number of Protestants in a church district. Counting sacrament participations is deemed relatively reliable because the established practice was to count the number of issued wafers from the number of wafers before and after the sacrament. The general Protestant norm at the time was to have Holy Communion only once a year (Hölscher 2001, p. 37), although there were regional differences. The possibility of multiple individual attendances, the possibility of attending Holy Communion outside the home parish, and the counting of non-confirmed children among the number of Protestants in the denominator constitute reasons why the indicator does not directly measure the actual sacrament participation of parishioners (see Becker and Woessmann 2013).

At the time, the data were regularly published in a comparative manner at the level of the Regional Churches. Hölscher (2001)'s “Data Atlas on the Religious Geography in Protestant

Germany: From the Mid-nineteenth Century to the Second World War” for the first time brings together the district-level data, gathered from regional archives, for the geographic coverage of modern-day Germany. Hölscher kindly provided us with digital versions of the data as published in the Data Atlas. After assigning IDs to every church district (*Kirchenkreis*) and cross-checking the data, we combined the data into one panel dataset. In few cases where data referred to double years, we assigned attendance numbers to the first of the double year.

The church attendance data have gaps for some church districts in some years. Where the year of interest was unavailable but a precedent and a subsequent year were available, we computed the linear interpolation between the years available to obtain an estimate of the church attendance in the year of interest. This was done in a total of 17 observations (3 in 1890, 4 in 1900, 1 in 1905, 3 in 1910, 1 in 1913, 1 in 1925, and 4 in 1930). Where only the precedent year, only subsequent years, or years very far from the point of time of interest were available, we computed a city-specific linear time trend and interpolated the closest available church attendance measure to the year of interest. This was applied in 30 church district observations translating to 34 city-year observations (9 in 1890, 4 in 1895, 1 in 1900, 2 in 1905, 4 in 1910, 3 in 1913, 4 in 1925, and 7 in 1930). Of the 51 imputed values of the dependent variable, 36 enter the merged dataset. Of these 36 observations, 32 enter our regression analyses. When dropping all observations that have an imputed value of the dependent variable, the number of observations that can be used in the regression drops to 259; the coefficient of education remains qualitatively unaffected in this smaller sample (Table 10, column 2).

Some notable changes occurred in the borders of church districts. Where a city changed districts, we assigned the district value in which the city was at the point of time. For the values of the number of Protestants in a church district taken from Hölscher (2001), we proceeded analogously to the imputation of church attendance. Where the value for either Protestants or church attendance was available and the other one was missing, we took the reported value and imputed the other one, where possible (Table 11).

Additional data

The Statistical Yearbooks of German Cities provide a number of additional data used in our analyses. As an indicator of city income, we use municipal tax revenues, which refer to total municipal tax revenues (*Gemeindesteuereinnahmen Gesamt*) in a city in a year. Because numbers were unavailable for 1925, we used the 1927 values, the first year after the year of interest in which tax revenues were available. Again, if double years were reported, we chose the first year where differences were minor. Where some of the entries were reported as double and others as single years, we took the single-year values where possible.

As a general rule, the population data are taken from the December count. This was not applicable in 1913, where we used the latest possible population data, from October 1913, to be as close as possible to the December standard. In 1925, the only population count available was from June. In 1930, only the average value over the entire year was available. If census data were available, we referred to this data source (in 1890, 1895, and 1910). The same sources also provide data on the share female.

The data on share of Protestants in 1910 were taken from the 1910 census. Where data were missing for the share of Protestants in 1910 in the yearbooks, we took the value of the 1910 census. The age structure is also extracted from the 1910 census and from the statistical yearbook of 1893, which includes tables of the 1890 census. For the data on new citizens, the yearbooks note in the introduction that figures are not very accurate as some cities counted

Table 10 Robustness samples and samples by protestant share. *Data sources* church attendance: [Hölscher \(2001\)](#) based on Sacrament Statistics; other variables: Statistical Yearbooks of German Cities ([Neefe 1892](#) through [Deutscher Städtetag 1931](#))

Sample	Cities observed in 1890 (1)	No imputations (2)	Similar district size (3)	Non-urban regions (4)	Above 50% Protestants (5)	Below 75% Protestants (6)	Above 75% Protestants (7)	Below 75% Protestants (8)
Enrollment rate in advanced schools	–1.310 (0.791)	–1.798** (0.692)	–1.389** (0.624)	–1.054* (0.538)	–1.708* (0.919)	–0.909** (0.425)	–0.818 (0.997)	–1.901** (0.759)
Municipal tax per capita	0.0005 (0.0005)	–0.00004 (0.0003)	0.0003 (0.0004)	–0.0005 (0.0008)	0.00007 (0.0006)	–0.0005* (0.0003)	–0.00009 (0.0008)	–0.0001 (0.0003)
Population (in millions)	0.0008 (0.011)	0.008 (0.011)	0.005 (0.010)	0.551*** (0.145)	0.005 (0.011)	0.110* (0.060)	0.013 (0.013)	0.077 (0.056)
City and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	173	259	223	111	175	116	130	161
Clusters	25	56	49	26	39	19	27	31
R ² (within)	0.501	0.458	0.490	0.719	0.468	0.672	0.595	0.490

Dependent variable: church attendance (participations in Holy Communion over Protestants). Unbalanced panel of 61 German cities with over 50,000 inhabitants observed in eight waves that cover every 5 years from 1890 to 1930 (no data for 1920; 1913 instead of 1915). Enrollment rate in advanced schools refers to enrolled students over city population. Column 1 excludes cities not already observed in 1890. Column 2 excludes observations with imputed dependent variable. Column 3 excludes cities where the number of Protestants in the church district is more than twice as large as in the city in 1910. Column 4 excludes cities situated in urban regions. Columns 5–8 divide the sample along the share of Protestants in a city in 1910. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

Table 11 Bivariate associations between different income measures and advanced-school enrollment. *Data sources* church attendance: [Hölscher \(2001\)](#) based on Sacramento Statistics; municipal tax per capita: Statistical Yearbooks of German Cities ([Neeffe 1892](#) through [Deutscher Städtetag 1931](#)); income tax per capita: Statistical Yearbooks and [Silbergleit \(1908\)](#); teacher income: [Galloway \(2007\)](#)

Dependent variable	Enrollment rate in advanced schools	Municipal tax per capita	Income tax per capita	Teacher income
Enrollment rate in advanced schools		0.377 (1.497)	0.121** (0.053)	16.672* (8.148)
Municipal tax per capita	0.001 (0.003)		0.009 (0.009)	1.040** (0.494)
Income tax per capita	0.830** (0.384)	6.489 (5.641)		56.965** (21.635)
Teacher income	0.005** (0.002)	0.026* (0.014)	0.002** (0.001)	

Each entry represents the coefficient from a separate fixed effects regression of the dependent variable shown in table header on the regressor shown in the first column. All regressions include city and year fixed effects. Unbalanced panel of 61 German cities with over 50,000 inhabitants observed in eight waves that cover every 5 years from 1890 to 1930 (no data for 1920; 1913 instead of 1915). Enrollment rate in advanced schools refers to enrolled students over city population. For ease of exposition, municipal tax per capita is measured in 100 Mark and teacher income is measured in 1000 Mark. Standard errors clustered at the church district level in parentheses: significance at * 10%, ** 5%, *** 1%

persons and others households. In 1913, we used the 1912 data for availability and in 1925, the 1924 data.

Yearbook data were taken from the statistical yearbooks of 1892, pp. 26–386, and 1893, p. 274 (both for 1890); 1895, p. 162, 1897, pp. 149–383, and 1898, pp. 162–264 (all for 1895); 1902, pp. 101–423, and 1903, pp. 110–267 (both for 1900); 1907, pp. 52–69, and 1908, pp. 380–474 (both for 1905); 1912, pp. 26–679 (for 1910); 1914, p. 481, and 1916, pp. 7–696 (for 1913); 1927, p. 66–355, and 1930, pp. 441–455 (for 1925); and 1931, pp. 367–519 (for 1930). The data from the census in 1910 were taken from pp. 132–162.

Data on vote shares were obtained from election results for the National Parliament (*Reichstag*) for the years 1890–1912 (available from the GESIS Data Archive for the Social Sciences, study number ZA8145, Voter movement in Wilhelminian Germany: The Reichstag elections of 1890–1912). Elections are not at 5-year intervals, so we matched 1890 election data to 1890 church attendance data; 1893–1895; 1898–1900; 1903–1905; 1907–1910; and 1912–1913. We linked our city-level data to the precinct (*Wahlbezirk*) in which they are located.

Our data on city-level income tax stem from the Statistical Yearbook VI (for 1890 and 1895) and IX (for 1900) as well as [Silbergleit \(1908\)](#) for 1905. The data on teacher income stem from the education censuses documented in *Preussische Statistik*, Vols. 101 (for 1886), 120b (for 1891), 151b (for 1896), 176c (for 1901), 209c (for 1906), 231b (for 1911), as available in [Galloway \(2007\)](#). Data on industry employment come from *Preussische Statistik*, Vol. 76b (for 1882) and *Statistik des Deutschen Reichs*, Vol. 109 (for 1895) and Vols. 204 and 209 (for 1907). The data on welfare expenditures stem from the Statistical Yearbooks III (for 1890), VI (1895), XVII (1905), XIX (1910) and XXI (1913).

Data on the opening of universities and on the number of university students are taken from [Eulenburg \(1904\)](#) until 1900 and subsequently from different volumes of the Statistical

Yearbook of the German Reich.³¹ In our city sample, only three universities opened during the time period (Frankfurt/Main 1914, Hamburg 1919, and re-founding of Cologne 1919).

We coded data on the number of Protestant, Catholic, and secular advanced schools, as well as the total number of advanced schools, in our city sample from volumes VII, XVI, and XXVI of the Statistical Yearbook of Advanced Schools and Remedial Institutions in Germany, Luxembourg and Switzerland (*Statistisches Jahrbuch der höheren Schulen und heilpädagogischen Anstalten Deutschlands, Luxemburgs und der Schweiz*).

Finally, our data on the number of schools and enrollment rates in different school types again stem from the Statistical Yearbooks II (for 1890), V (1895), XI (1900), XV (1905), XVIII (1910), and XXI (1913). For two cities in 1895, we use the value of 1892; for one city in 1905, we use the value of 1903/4; and for one city in 1913, we use the value of 1911/12. These data are mostly unavailable for female students. Also, data on separate school types are only available up to 1913. Whenever schools are of multiple school types, we code the data in the same category as in the Yearbook. *Gymnasien* generally include *Progymnasien*, which represent the first years students go to the *Gymnasium*.

Merging the datasets

We used the church district data to merge the two datasets. Where it was unclear in which church district a city was at the time, we used geographical matching to assign the church district in which the city was in 1910. Where cities changed in their adherence to a church district, we used the largest available district for clustering and assigned the fraction of communion attenders of the church district in which the city was at the specific point in time.

If a city's value was reported in more than one data point (e.g., large cities where the church district was split into urban and rural districts), we used the largest church district related to the city (that is, the urban one). In cases in which the split and merge of church districts was unclear, we refrained from using the data. Hölcher (2001) reports data for modern-day Germany, with the exception of the Province of Brandenburg (except for Berlin) and Western Pomerania. Due to this limitation, our analysis does not cover some Eastern parts of modern-day Germany and the parts of the German Reich not located in modern-day Germany (esp. the Eastern Provinces located in modern-day Poland and Russia).

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³¹ We are grateful to Stephan Heblich for providing us with the latter data.

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